

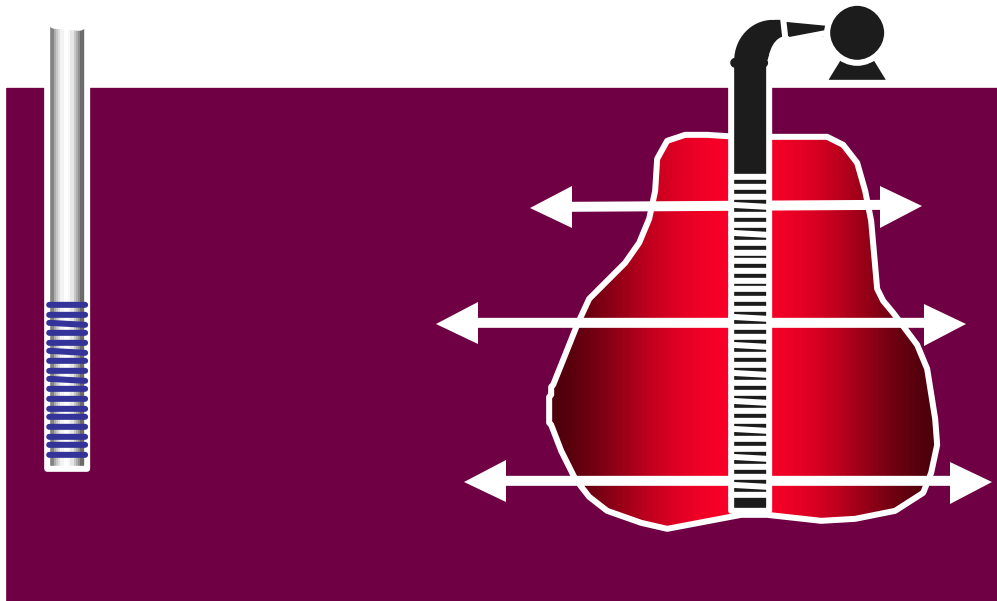


# 2003 AFCEE Technology Transfer Workshop

San Antonio, Texas

*Promoting Readiness through Environmental Stewardship*

## Bioventing – Please Keep It Simple!



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Air Force Real Property Agency



# Overview

- Underlying principles of the bioventing pilot test
- Purposes for the pilot test
- Sampling impacts and lessons-learned
- Application to operating bioventing systems
- Observations from a decade of application

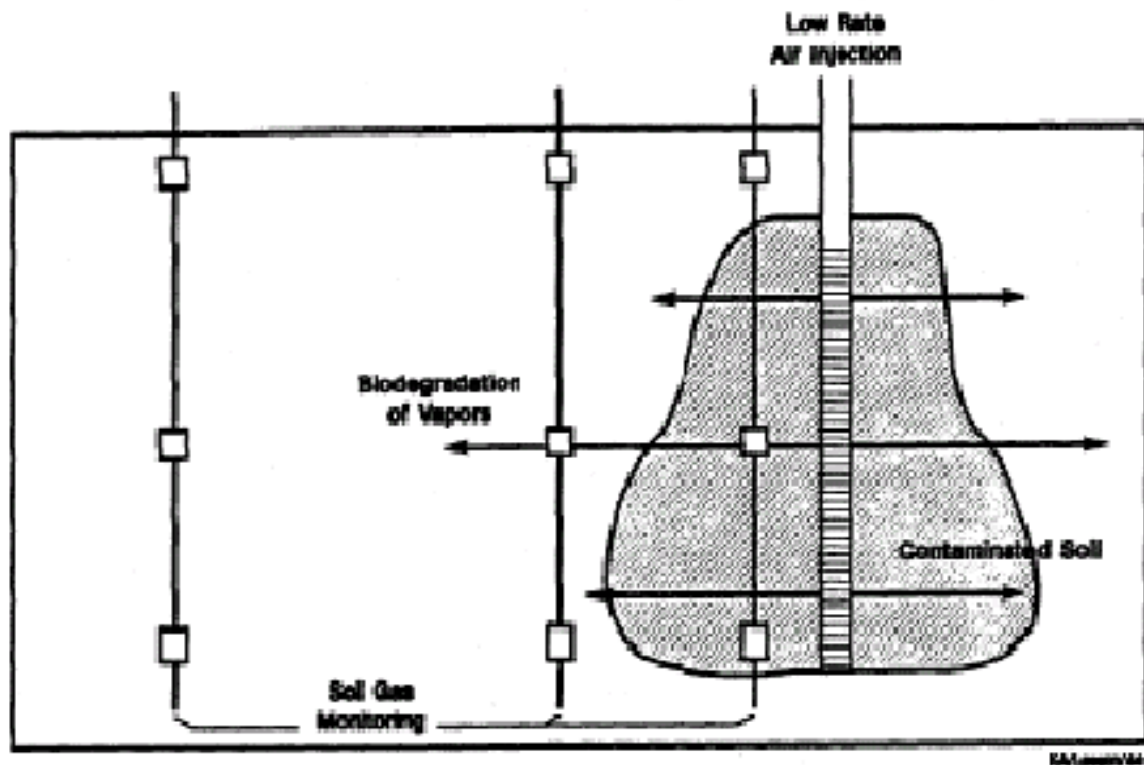


# Bioventing Pilot Study – Underlying Principles

- The technology was not proven and pilot tests had to provide indisputable evidence that the technology worked
- Air and helium injected during respiration test
  - Ensure you were extracting the injected air
  - Ensure you were not diluting or short circuiting
  - Prove that respiration was occurring



# Vapor Monitoring Points





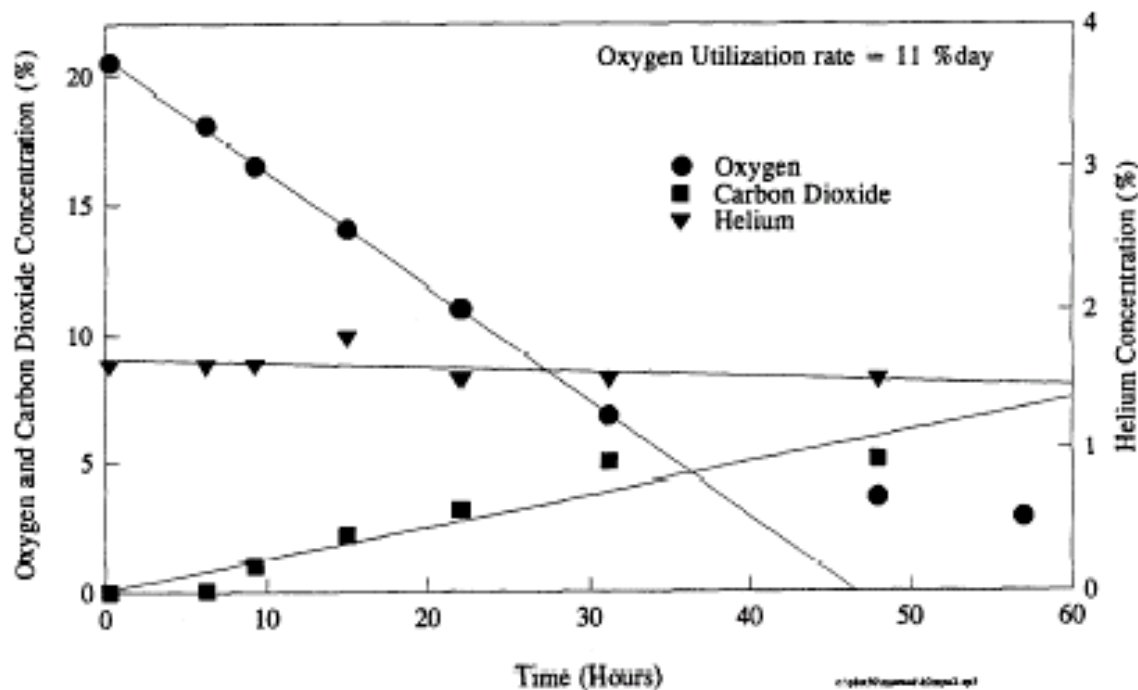


# Injecting Air and Helium





# Respiration Test Using Helium





# Bioventing Pilot Study – Lesson Learned

- Bioventing is now a proven and well understood technology
- People expect respiration to occur at fuel sites
- Helium injection determined not necessary at most locations if sampling is conducted carefully
  - Only a small percentage of VMPs found to be leaking
  - Adds additional level of complication/error
- Certainly not necessary for operating systems



# Bioventing Pilot Study–Purpose

- Evaluate site potential
- Provide information for system design

## WARNING:

- Protocols are based on lessons-learned
  - Single biggest problem is sampling technique
  - Sampling problems discovered during technology development
  - Take advantage of our bad experiences by avoiding them



# Site Potential

- Screen site for biodegradation potential by collecting and evaluating oxygen and carbon dioxide concentrations in soil gas.
- If you have high TVH and high oxygen the site has little potential
  - Experience indicates this will almost never occur
    - Less than 5% of fuel sites don't respire
  - If this happens at your site rule out poor sampling technique first



# Site Potential (Cont)

- Determine if bioventing will likely increase degradation rate
- If site has greater than 5% oxygen, bioventing probably won't help
  - It's a zero-order reaction
- Poor sampling technique could inappropriately disqualify a site
  - Atmospheric air leakage in probes or sampling train is the root-cause of most problems
  - A 0% O<sub>2</sub> site turns into a 5% O<sub>2</sub> site with only 25% leakage

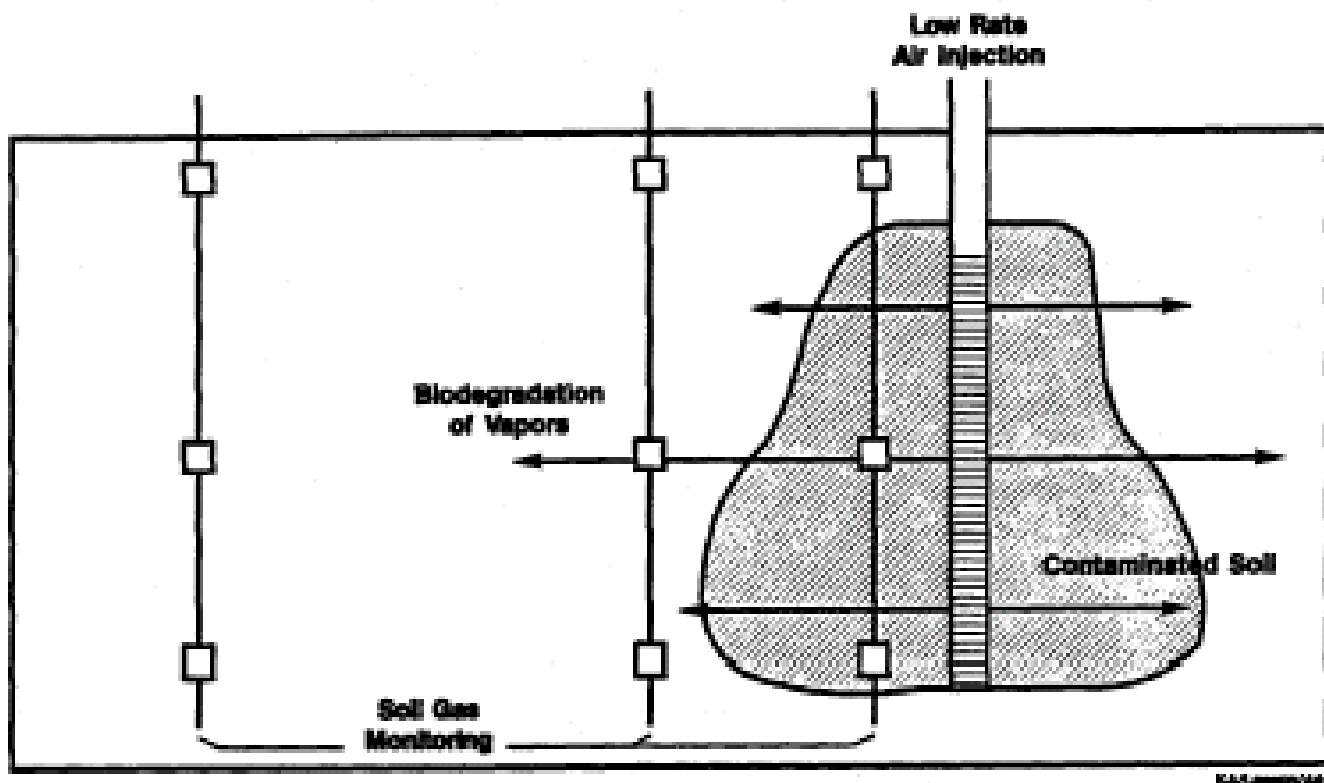


# System Design

- Determine the air injection or extraction radius of influence (ROI) for system design
- Use SVE methods
- Rule of thumb -  $> 1''$  H<sub>2</sub>O vacuum/pressure



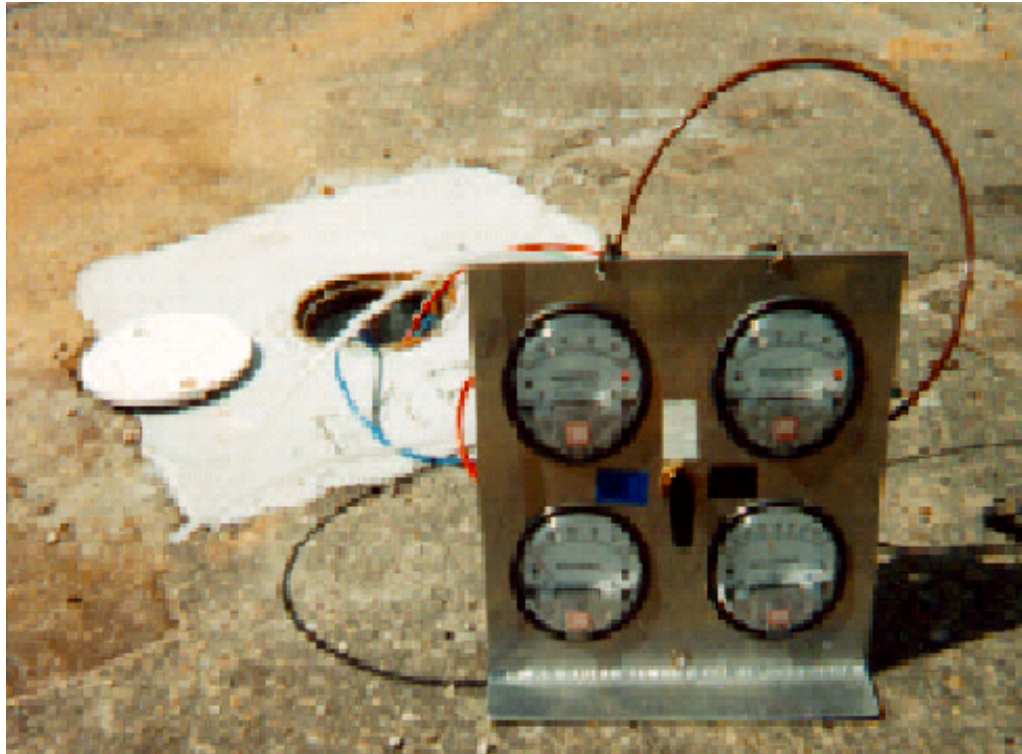
# Typical Bioventing Schematic





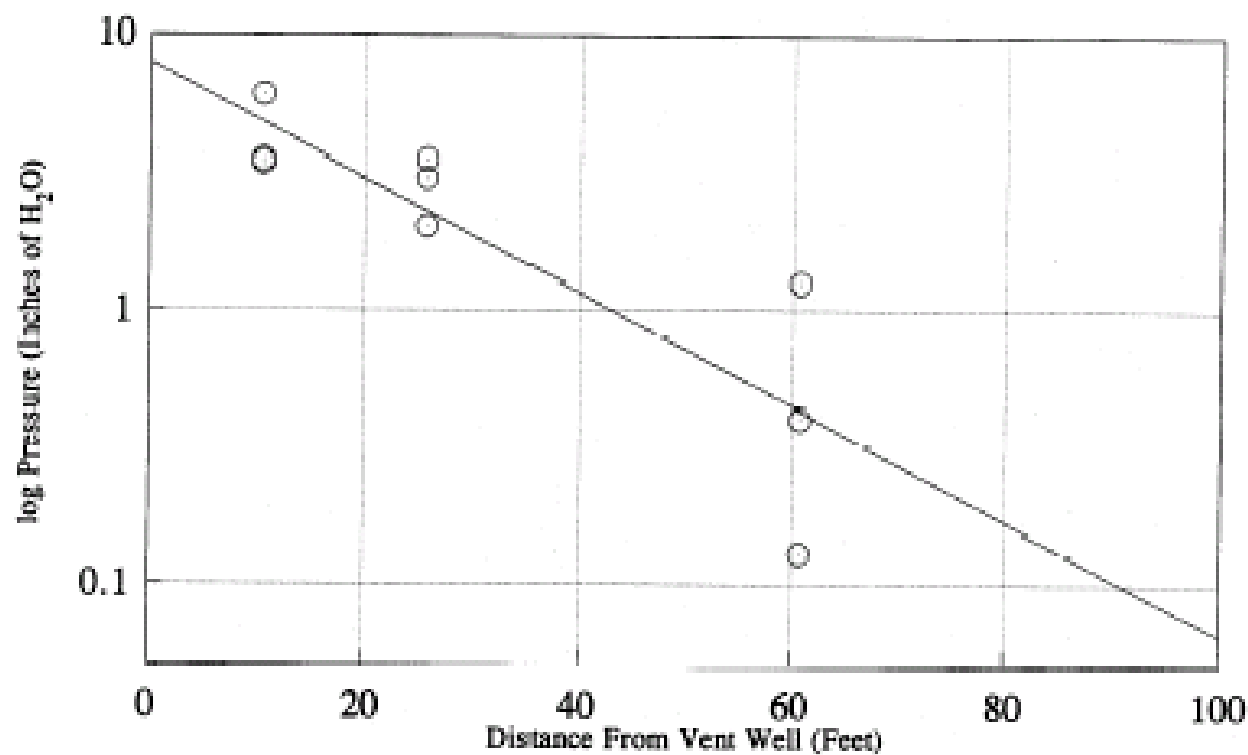


# Pressure Measurements in VMPs





# Air Radius of Influence





# System Design (Cont)

- Determine the oxygen radius of influence for system design
- This requires a respiration test to measure oxygen utilization rate – Helium injection not necessary
- Using air injection ROI, and oxygen ROI, design system spacing and injection rate
- Consider how rapidly respiration rates are likely to decline
- Spacing larger than initial oxygen ROI is probably optimum



# Uses of the Respiration Test

- Determines oxygen ROI for assisting in design
  - Not the sole basis; use experience
- Provides integrated estimate of remedial progress
- Provides best indication of when site is clean
- ESTIMATES fuel biodegradation rate/mass removal



# Sampling Impacts and Lessons

- Direct reading equipment is designed to operate at atmospheric pressure
- Direct reading sampling equipment can not be used to pull the vacuum
- High potential for leakage and dilution with atmospheric air
  - Misinterpreted as low or no respiration or generally high site oxygen
  - Could discourage use of the technology

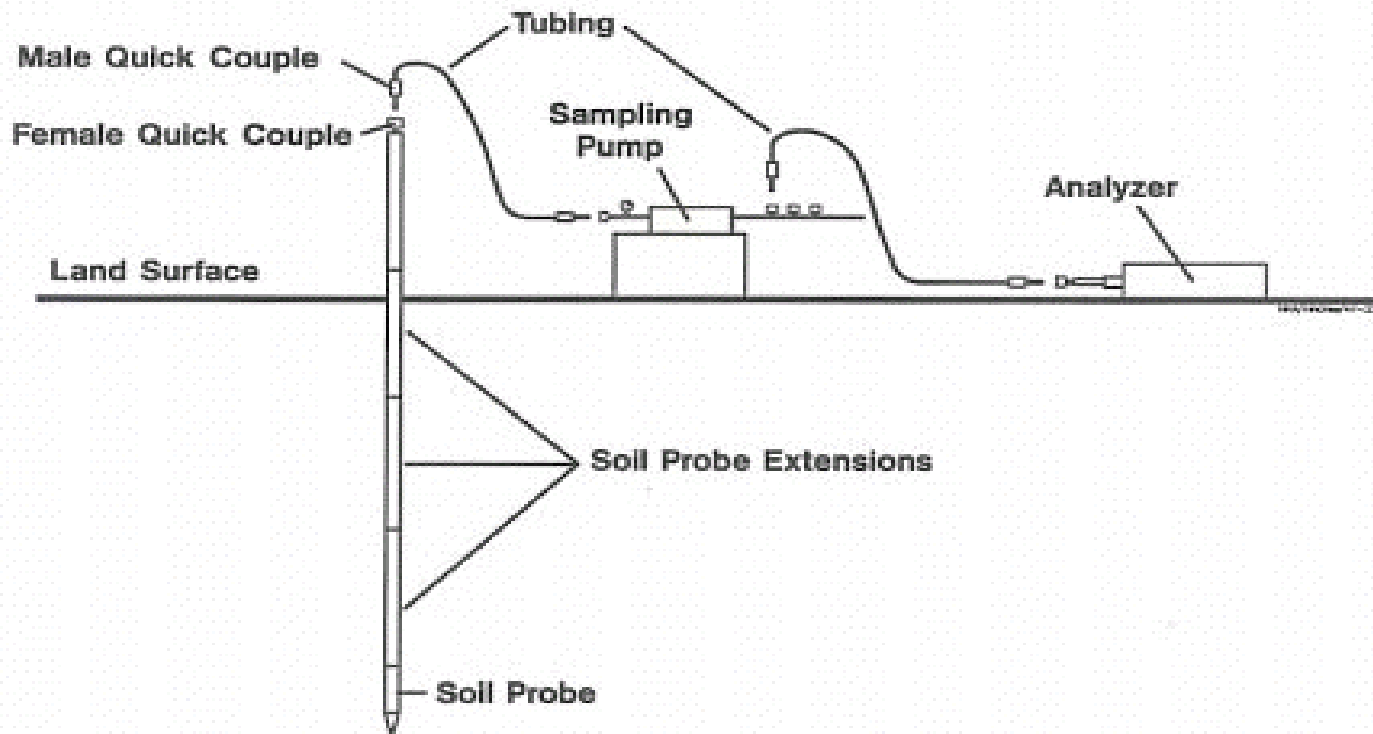


# Sampling Impacts and Lessons(cont)

- Never use field O<sub>2</sub>/CO<sub>2</sub> meters to extract soil gas
  - They will leak atmospheric air if under vacuum
- Always use vacuum pump assist as shown in design manual
- Some lower quality vacuum pumps leak under vacuum
- Connect meter to a side stream only to maintain atmospheric pressure – never connect direct
- Make sure there is excess air discharging



# Atmospheric Pressure Sampling





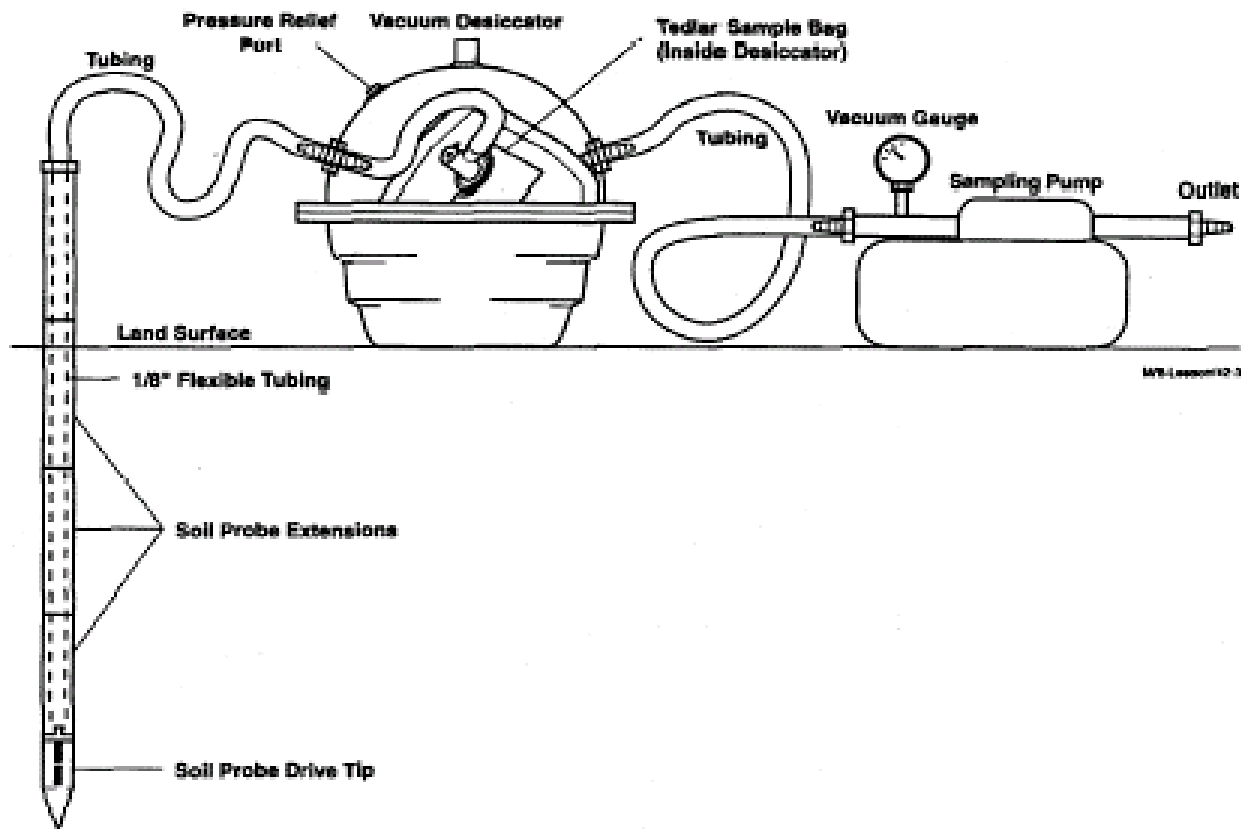
# Sampling Impacts and Lessons(cont)

- Check by using Tedlar or Mylar bag and a vacuum desiccator
- Compare vacuum desiccator measurements to those from the discharge of the sampling pump
- If no leakage then it's faster and more accurate to sample from the discharge side of the sampling pump
  - Allows you to better watch and catch O<sub>2</sub> low point





# Vacuum Desiccator





# Sampling Impacts and Lessons(cont)

- Watch oxygen concentrations to capture low point
  - Clearly shows when purging is complete
  - Too much purging can bring in atmospheric air in shallow probes
- Careful sampling and cross checking eliminates need for helium injection
- Direct reading instrument (LEL/explosive meter) best for collecting hydrocarbon concentrations
  - Catalytic detector linear over a wider range than FID

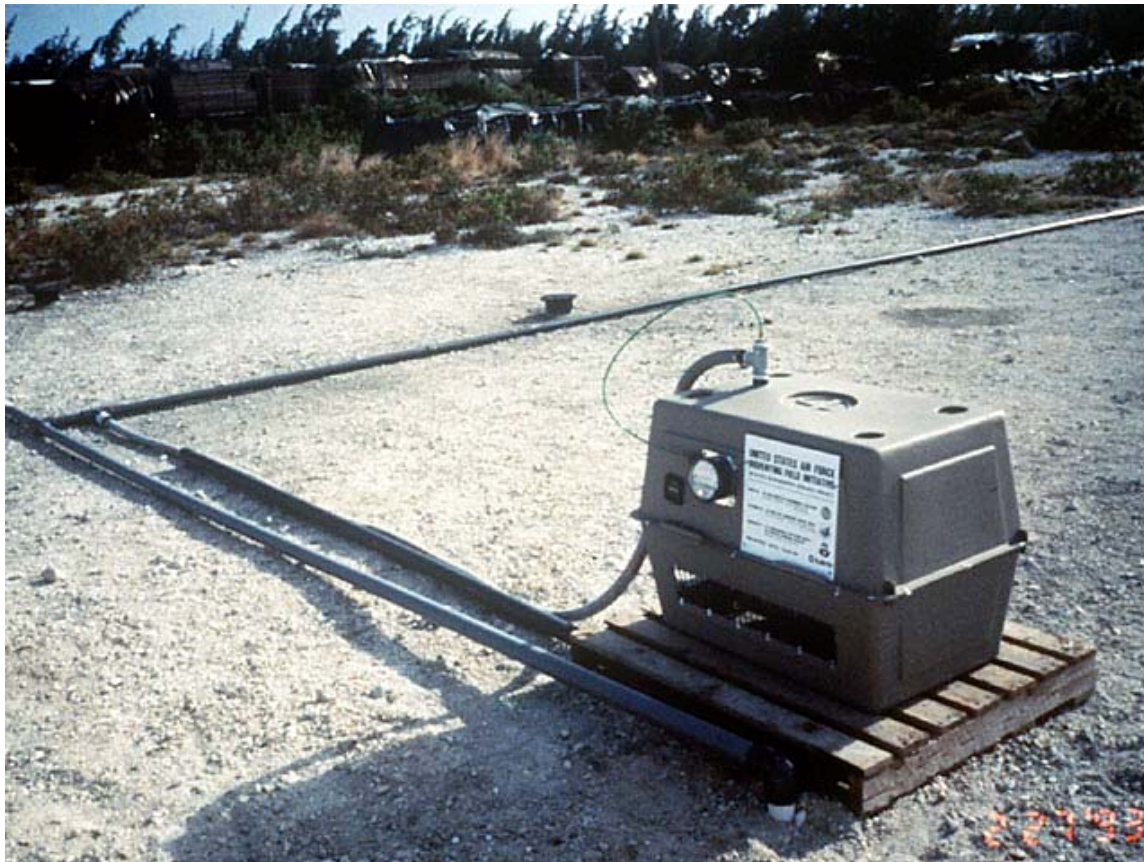


# Operating Bioventing Systems

- An operating system is a sold system
- No longer need pilot level detail
- Periodic (annual) respiration tests to monitor progress
- Respiration test provides integrated estimate of remedial progress



# Operating Bioventing System



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# Operating Bioventing Systems (Cont)

- Avoid periodic soil sampling to measure progress
  - Variability is recipe for confusion
- Minimizing OM&M encourages longer operation
  - “JUST SET IT AND FORGET IT” - almost
- Never inject air or helium into VMP on an operating system for respiration test
  - It's not a pilot test anymore
  - Helium not needed even for pilot test



# Operating Bioventing Systems (Cont)

- If the VMP doesn't show  $>5\%$  oxygen during operation adjust injection spacing and/or flow rate
- Get initial oxygen and carbon dioxide while system is running
- Bioventing systems do not require  $20.9\%$   $O_2$ 
  - Zero-order reaction
  - Minimize air flow to minimize volatilization
  - VMPs at  $8-15\%$   $O_2$  is probably optimized
- Turn off blower/s and start respiration test
  - Don't need  $20.9\%$  oxygen to start test



# Operating Bioventing Systems (Cont)

- Delay soil samples until respiration rate is at background rates
  - Minimizes unnecessary, costly, and confusing soil data
- Minimize periodic vapor sampling
  - What will you do with it?
  - Useful is cleanup based on specific compounds (BTEX)
    - Not useful if cleanup based on TPH, DRO, or GRO
- ESTIMATE fuel biodegradation rate/mass removal but don't overemphasis



# Operating Bioventing Systems (Cont)

- Don't get caught up in quantifying mass removal rate
- Intended as an estimate only
- Not really important since starting mass is never known
- Focus is on oxygen utilization rate for determining endpoint





# Operating Bioventing Systems (Cont)

- Minimize OM&M costs
- Avoid the trap of collecting periodic soil samples
- Know how you will use any periodic VOC data or don't collect it
- Minimize respiration tests (annual is adequate)



# Operating Bioventing Systems (Cont)

- Keep it running and keep it simple
- Consider hard-wiring so system does not need to be restarted after power outage (only for injection mode)
- Use telemetry technology to check on operating status
- Understand the pitfalls of periodic sampling and fight against it
- Attention to the sampling details and minimizing monitoring will maintain bioventing as a viable low-cost technology



# Bioventing

- Please keep it simple!!

It's not a 10 lb turkey but:

- “Just set it and forget it” – almost





# References

- Test Plan and Technical Protocol for at Field Treatability Test for Bioventing (1992)
- Addendum One to Test Plan and Technical Protocol for at Field Treatability Test for Bioventing. Using Soil Gas Survey to Determine Bioventing Feasibility and Natural Attenuation Potential
- Principles and Practices of Bioventing (1995)
- Documents available on the AFCEE website